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October 4, 1999

Magalie Roman Salas, Secretary
Federal Communications Commission
Portals II Building, TW-A325
445 - 12th Street, S.W.
Washington, D.C. 20554
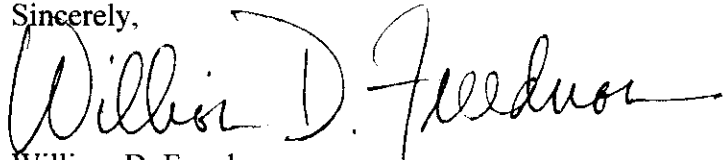
DOCKET FILE COPY ORIGINAL

> Re: Amendment of Part 15 of the Commission's Rules
> Regarding Spread Spectrum Devices
> ET Docket No. 99-231

Dear Ms. Salas:

On behalf of Aironet Wireless Communications, Inc. and in response to the Commission's Notice of Proposed Rule Making, FCC 99-149, released June 24, 1999, enclosed please find five (5) copies of its Letter Comments in the above-noted rule making proceeding.

Should you have any questions concerning this submission, please contact undersigned counsel.

Sincerely,

William D. Freedman

Enclosure

cc: Chairman William E. Kennard
      Commissioner Susan Ness
      Commissioner Harold Furchtgott-Roth
      Commissioner Michael K. Powell
      Commissioner Gloria Tristani
      Dale Hatfield, Chief, Office of Engineering and Technology
      Julius Knapp, Chief, Policy and Rules Division
      Mr. Neal L. McNeil
      Karen Rackley, Chief, Technical Rules Branch
      Mr. John A. Reed
      Anthony Serafin, Esquire

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Aironet

October 1, 1999

Magalie R. Salas
Secretary
Federal Communications Commission
445 12th St. S.W.
Washington D.C.

Dear Ms. Salas,

Aironet Wireless Communications, Inc., a developer and manufacturer of both frequency hopping and direct sequence spread spectrum communications equipment, respectfully submits the following comments in response to NPRM 99-149 (ET docket 99-231):

I. Wide Band Frequency Hopping

Aironet opposes the proposed rule change that would allow FHSS radio channels to increase to 3MHz or 5MHz bandwidths, based on the findings of our interference testing. To analyze the proposed frequency hopping changes, Aironet measured existing 1MHz systems with co-channel interference, with partial overlapped-channel interference, and with off-channel interference signals using the IEEE802.11 Desensitization test method. We found that offset FM modulated signals such as those produced by the NPRM's partially overlapped channels, exhibited up to 7dB more degradation in receiver Desensitization tests as compared to interfering FM signals centered on the channel (co-channel interference). See the plot of our test results in Figure 1 below.

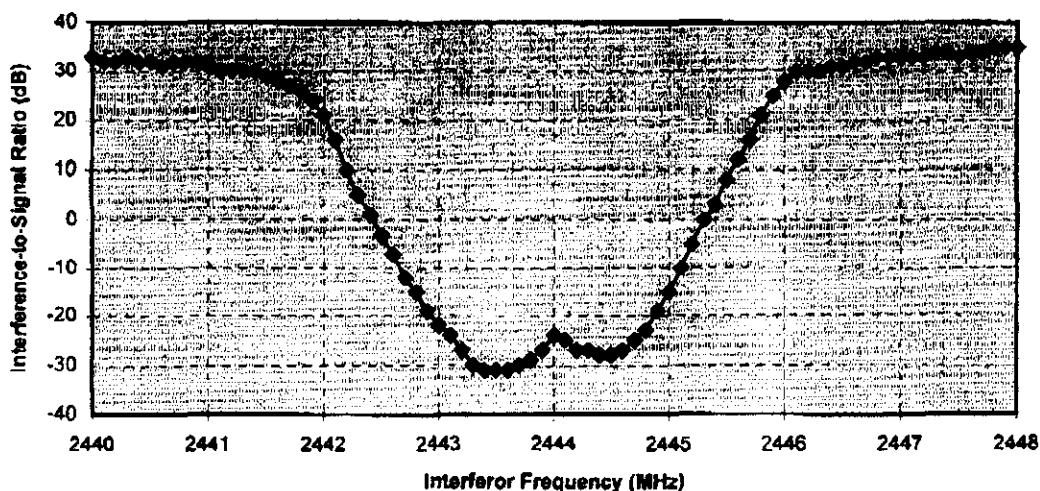**FHSS Desensitization (interference) Test Results**

Figure 1. Receiver Desensitization for 4-level GFSK (Desired Signal at 2444.0 MHz)

Test results for an IEEE802.11 FHSS radio with 4-level FSK (2Mbps) modulation are shown in Figure 1. The desired receiver signal was at 2444.0 MHz. Each diamond shaped point on the plot is an actual measured data point that represents the center frequency and RF level of an IEEE802.11 FHSS interference signal which the receiver could withstand or reject while still receiving the desired on-channel signal. The higher the point on the vertical grid (Interference-to-Signal Radio), the more desensitization protection the radio has against interference at that frequency offset. The lower the point, the less rejection there is to that interference signal. Our conclusions from the data are:

1. Unwanted FM modulated signals centered on-channel must be -23 dB (less power) relative to the desired signal in order to not interfere with the desired signal.
2. Interference rejection of signals centered at the next adjacent channels 1MHz to either side, is only a few dB better than centered on-channel interference rejection
3. Partially overlapped channel interference (offset carriers not centered in the channel) with FM modulation, actually resulted in worse interference than either centered co-channel or adjacent channel interference, as seen by an FM frequency hopping receiver.

Interpretation of Results

While this test was conducted on existing IEEE802.11 FHSS radios with 1MHz wide mutually exclusive channels (by definition), it points out what would happen with the proposed wide bandwidth FHSS receivers where 4 additional 5MHz wide channels would overlap each and every FHSS channel's bandwidth. In other words, we tested 1MHz wide channel systems with an interfering signal at various $1/10^{th}$ fractional channel spacings (100KHz) from the center of the channel to see the effect of overlapping channel signals. It is our conclusion that overlapped channels do not preserve any spread spectrum processing advantage and further that it contributes to considerably worse cross-channel interference than systems with mutually exclusive channel definitions. This is particularly true with FM systems where the nonlinear 2nd order demodulation effects due to frequency offsets causes a worse (than co-channel) reaction to the interference at the FM demodulator (up to 7dB worse at half channel offsets as shown in Figure 1).

While it is felt that these results can reliably be extrapolated to 5MHz channel systems, we are also conducting laboratory tests with 5MHz radio channel bandwidths to verify the above conclusions. This 5MHz channel bandwidth test data will be presented in our NPRM Reply Comment following this initial comment. We have determined that increasing the FHSS channel bandwidth to 5MHz, while at the same time maintaining the channel spacing at 1MHz, would result in multiply overlapped channels and a correspondingly significant increase of interference in the 2.4 GHz band. In contrast, today's non-overlapped channel assignments allow orthogonal hopping patterns to be employed. Wideband overlapped channeling precludes the possibility of designing effective orthogonal frequency hopping patterns.

Additionally, Aironet objects to the Wideband Frequency Hopping spread spectrum (WBFH) proposal based on the following points:

1) WBFH systems operating on these overlapping channels will open their receivers to as much as 5 times increased susceptibility to interference from existing systems (wider receiver channel) as well as create increased co-channel interference to other receivers.

2) The proposed linear reduction in power is not adequate to reduce the increased interference within these WBFH systems. Currently FHSS systems operating under Part 15.247 rules with 1MHz channel bandwidth are largely operating at transmit power levels of around 100mW which is less than the reduced maximum transmitter power levels proposed by this NPRM. The proposed reduction in power for WBFH systems would not provide any decrease in interference for current FHSS systems. The NPRM suggests that reducing the power by a factor of 3 (4.8dB) would mitigate the 3-times overlapping of wideband frequency hopping channels. It also suggests a 5-times reduction of power (7dB) would adequately reduce the increased interference caused by 5 channels partially overlapped. It has long been established that a linear decrease in power is not adequate to reduce co-channel interference but that the power should be reduced by at least the square of the increased interference power (channel overlap). Likewise to suggest that reducing the allowed output power from the FCC limit of 1 Watt down to 200mW would be a 5-times reduction of interference for 5MHz channels is not supported by factual data. Again, most Part 15 unlicensed devices in the 2.4GHz band are operating at significantly lower power (100mW) levels than the 1 Watt maximum. This is due to the fact that power supply current is used less efficiently at these higher frequencies than in lower bands due to physical properties of RF devises. Therefore battery powered equipment would suffer significantly reduced operating time at 1 Watt transmitted power levels. Furthermore the RF Exposure issue becomes a concern above 600mW. The net effect is that currently a greater number of unlicensed devices in the 2.4GHz ISM band are designed to operate at or near the European transmitted power limit of 100mW. We would ask that the power level of these broadband frequency hopping devices be reduced below 100mW by 3-squared (9-times) for the 3MHz channels and 5-squared (25-times) for the 5MHz channels. This equates to 9.5dB reduction in power below 100mW (20dBm) for a maximum of about 10dBm for 3MHz channels and 14dB below 100mW for a maximum of 6dBm for 5MHz frequency hopping channels.

3) The effects of multipath on the signal will degrade the performance of the WBFH systems. Using a single ray model it was found that a 50 nsec delay with 1 dB attenuation had a detrimental effect on the signal depending on where the null of the multipath signal was located. The finding was that about 24% of the channels will have severe performance degradation in a 10Mbps system with 5MHz channel bandwidths.

For the above technical reasons, Aironet is opposed to the Wideband FHSS proposal in this NPRM.

II. Direct Sequence Processing Gain Measurement

The NPRM 99-149 also proposes changes to the processing gain measurement method for direct sequence spread spectrum devices. Aironet is not opposed to a simpler jamming margin test based on noise interference in place of an interference CW (carrier) signal as is used today. However, we feel there needs to be more definition of the noise source and a simpler definition than some are proposing. We will here propose using the effective noise bandwidth of the receiver IF channel filter, as is done for a Signal-to-Noise Ratio (SNR) measurement, in the calibration of the interfering noise source.

Using a Guassian noise interferer instead of a CW interferer has several advantages:

1. Guassian noise interference provides for a simpler test than the current CW method and is a lot less time consuming. The CW jamming margin test requires a test point at every 50KHz. Across +/-8MHz this is 320 points. With four data rates to be tested, this requires 1280 measurement points. Using a Guassian noise test requires only one point per data rate, since this test is frequency independent. Therefore, the time required to test a radio would be reduced considerably (reduced from 1280 test points to only 4 test points, one for each of the four data rates of 1, 2, 5.5 and 11Mbps).

2. The Guassian noise interferer is a more direct way of measuring overall processing gain, PG, since PG is defined as a signal-to-noise improvement with spreading. The processing gain formula is PG=S/N(unspread) − S/N(spread). the most direct method of measuring S/N(spread) is by feeding a signal and a calibrated noise level directly into the radio antenna. Today's use of a CW interfering signal as a jammer only approximates a typical noise (interference) source.

Measuring the effective noise power at the receiver is a critical part of setting up the PG test. To measure noise power one must know the effective noise bandwidth of the receiver. In a typical superheterodyne radio, the IF filter bandwidth determines the effective noise bandwidth of the receiver. In order to measure the S/N one must measure the two components, signal and noise, separately. The test signal power, S, can be directly measured using a power meter. Measuring the noise power, N, is a two step process. First, connect the Gaussian noise source to a spectrum analyzer centered at 2.4GHz with a resolution BW of 1MHz and video BW of 1KHz. Read the displayed broadband noise power level as a reference level in dBm. Then a calibration factor must be added in dB to account for the effective noise bandwidth of the receiver. The effective noise bandwidth of the radio IF filter must be known from the filter design or be empirically measured. The processing gain formula would be as follows:

PG= S/N(unspread) − S/N(spread) + system losses(up to 2dB)

Where:

S/N(unspread) = measured or theoretical modulation S/N (PSK) without spreading

S/N(spread)= signal(spread)/noise = signal(dBm) − noise(dBm)

Signal spread(dBm) = power read on a power meter

Noise(dBm) = power on spectrum analyzer + IF bandwidth calibration factor (in dB)

Example; PG = 13dBm − 3dBm + 1dB = 11 dB processing gain
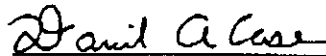
DSSS Processing Gain Conclusions:

Based upon our testing results, we found the Guassian noise and the CW jamming sources produced similar results with today's DSSS receivers. Aironet favors changes to the Direct

Sequence Processing Gain measurement method as proposed in the NPRM provided it includes a simple S/N measurement procedure similar to the one described above.

Respectfully,

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